TERRACE INTERPRETATION IN SOUTHEASTERN OHIO

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The terraces along the Ohio, Muskingum, Hocking, and Scioto rivers have attracted agricultural and physiographic interest for many years and have elicited several papers. It is believed that they can make a contribution to the glacial as well as to the river history of Ohio. To this end the author added to his previous studies extending over years of investigation a complete journey along these four rivers in the summer of 1953 from East Liverpool to Portsmouth on the Ohio, up the Muskingum to Zanesville, down the Hocking from Lancaster, and up the Scioto to Columbus. These terraces are not studied here as terrace patterns in the manner that terraces were studied by several able students at the turn of the century but rather as materials related to the several ice advances and to stream work.

Many authors in their reports by counties, by areas and by topics in the Ohio Geological Survey both of the Third and the Fourth Series have mentioned and often described terraces along these through streams in unglaciated Ohio. There are very few terraces along streams that do not reach back into glaciated Ohio, and none of glacial outwash or valley train material. How could there be outwash in valleys that never headed near the ice margins?

As has been known for many years, all four rivers have suffered modification as recently as in the glacial period. The narrow valley on the Ohio from Sardis, Ohio, to St. Marys, W. Va., indicates that two rivers once flowed in opposite directions from this section. The absence of any large tributaries in this vicinity also points to this as a divide area. The narrow valley from Duncan Falls to below McConnellsville on the Muskingum suggests a similar situation on this river. Likewise, the narrow place from the Athens-Washington County line north to Frost, and again below Haydenville on the Hocking indicate that streams, formerly flowing in different directions, were connected to make up this through river. The Scioto has probably been reversed from Sciotoville at the mouth of the Little Scioto River nearly to Columbus. These four changes will be reviewed later in this paper each under its own river.

The terraces are mostly of gravel and sand, are both high and low, some over 1,000 ft. above sea level (350 ft. above the river); the lowest just above river level, are mostly of gravel and sand. Some are of local fallen material or bed rock in place, others of rock covered with gravel and sand. The detrital material containing varying proportions of crystalline pebbles evidences glaciers from a Canadian source as one of the transporting agents. Except in the lowest terraces, which are flood-plain remnants and contain relatively little in the way of crystalline pebbles, the fragmental material of the terraces is interpreted to be glacial outwash. Inasmuch as the outwash displays various stages of weathering it is believed to have reached its present lodgment at different times and to have been exposed to weathering for different durations.

THE OHIO RIVER

That the Ohio River is a composite river has long been recognized. Old divides have been recognized near Cincinnati, below Cincinnati in the Kentucky-Indiana portion, at several places between Portsmouth and Marietta and again near Sardis. Other modifications occurred farther upstream in Pennsylvania. These modifications were not all accomplished at the same time but are ascribed,

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some to Teays and Deep Stage time, others to pre-Illinoian glaciation time and to Illinoian and Wisconsin times Stout and Lamb, 1938. (p. 80).

The Ohio Narrows. The long reach or gorge section of Ohio River is a nearly straight, narrow valley from St. Marys to New Martinsville, (fig. 1) two towns in West Virginia. This portion has been interpreted as a gorge, and its youthful appearance ascribed to the recency of the coming of the river through this part. It has been held by Stout and Lamb (1938) that Ohio River did not transgress this col in pre-Illinoian time, but that Illinoian ice forced water over the col. They also believed when they wrote that ice on the Ohio near Ripley midway between Cincinnati and Portsmouth, obstructed the westward outlet (Cincinnati River) and set water back up Teays, over Sardis area, and on northeastward toward the Atlantic. This of course occurred after Sardis col had been cut out by some previous transgression. Ireland (1940, 1943) finds crystalline pebbles and boulders high on hills in southeastern Ohio, pre-Illinoian outwash in valleys, and drift known in Western Pennsylvania that are all equivalent in weathering and erosion to Jerseyan (Nebraskan) rather than Kansan. He says with Leverett (1926, 1939) that Pennsylvanian drainage at this time went southward through the Sardis-New Martinsville gorge section.

Inspection in the field and a study of the topographic maps eliminate most of this "gorge" section as the exact site of the former divide. One mile above New Metamoras the 1,000-foot contour line lies on the bluff ¼ mile from the flood plain on the West Virginia side, and 920-foot line (top line on map) is ½ mile from the flood plain on the Ohio side. The two strips of flood plain and river combined are less than ½ mile wide; hence the bluff summits are only about one mile apart at this place. About 2 miles south of Sardis on the Ohio side the highest contour is 1,200 ft. and ¼ mile distant from the flood plain and on the West Virginia side is 1,160 ft. and ⅓ mile from the flood plain. The river and flood plain total just over ¾ mile; hence the bluff summits here, while a little higher than near New Metamoras, are 30–35 percent farther apart. Inasmuch as the New Metamoras "pinch" is in a narrower gorge section we are inclined to think that the transgressed col was at this place rather than near Sardis; but the ambiguity suggests a capture by head erosion (headward or headstream erosion) rather than a simple "push over" by glacial waters.

Looking for other possible similar cols over which the waters might have been forced, we find that the Wetzel-Tyler county line (fig. 1) is laid for many miles along a divide east of the Ohio River, starting near the river and extending southeastward with an altitude of about 1,000 ft. It rarely falls even a little below. This divide lies between tributaries of Fishing Creek and Middle Island Creek.

On the Ohio side of the Ohio River is a divide ridge between the tributaries of the Little Muskingum and Sunfish rivers that is about 1,200 ft. above sea level at Woodsfield, and does not depart far from that altitude. These divides probably have been lowered a little since the beginning of the ice age, but they must have been higher than the col near New Metamoras when it was first transgressed, else they would have been crossed instead. The Little Muskingum and Sunfish are in much more mature valleys than the present Ohio, especially near its narrow places, and Middle Island and Fishing creeks have very meandering courses in equally mature valleys. No doubt these four have matured some since the Ohio diversion, while the Ohio Valley has been touched up, much widened in places, to satisfy the needs of a larger stream than those in it before the diversion. When the ice-ponding occurred water went over the New Metamoras col because it was a little lower than any of the others; no matter whether the diversion was due to ice ponding or to earlier stream capture.

Terraces in the Ohio Valley. Terraces are found along the Ohio River from its beginning at Pittsburgh throughout its whole course. We shall examine only those in Ohio and above Portsmouth. There are many on the opposite side in

West Virginia and in Kentucky. No continuous bench can be traced for a long distance, but patches of terrace, more or less intact and nearly level-topped, are constantly in sight. The terraces are at various altitudes from over 1000 ft. above sea level down to stream level. From Beaver River south to New Martins-

FIGURE 1. Map, Ohio River from Pennsylvania line to Marietta with counties and towns.

ville, all but the highest descend with the present stream, the upper detrital ones more rapidly. The highest terrace series is of rock, free from outwash, and descends northward. Upper gravel ones are generally more deeply and severely

weathered and are more dissected. The lower ones approach the present flood plain, both in altitude and in nature of materials; as the river continues to cut down and lower its grade, remnants of the existing flood plain will be preserved and will then be counted as terraces.

Gravel-covered Terraces. The highest gravel and sand terraces on the Ohio River now occur over 900 ft. above sea level from East End above East Liverpool to Toronto in Jefferson County. At the latter place they are about 950 ft. They are primarily of bed rock, sometimes called gradation plains (Chamberlin and Leverett 1894) and are more or less covered with gravel or sand on top. The terrace top falls gently southward. They may be seen up the slope back of Vulcan on both sides of the little run and back of Wellsville a half mile north of McQueen Run. The continued presence of crystalline pebbles, granite, gneiss, quartzite, and schist of Canadian origin, shows that the material is certainly outwash from a glacier or from a moraine or till sheet. Its much weathered condition means that it came from very early glaciation, Stout says, Nebraskan, (Jerseyan) and the author concurs. It is far older than known Illinoian gravels. While the terrace top falls southward from place to place, the rock terrace below the gravel falls northward. These descents indicate that the rock terraces were made by a north-flowing stream before the diversion; and the gravel, falling southward, was laid by a south-flowing stream, hence after the diversion. Since the terrace material is old enough to be called Nebraskan and lies in a valley made before the gravels came, the valley over the col at New Metamoras must have been opened not later than Nebraskan time.

Leverett (1903 p. 88) furnishes valuable light on this problem by pointing out many rock terraces higher than the gravel-topped ones that descend northward along the river from Moundsville, W. Va. to the present mouth of Beaver River, Pa., and others less frequent 10 to 12 miles south of Moundsville. These suggest that the reversal of drainage here may have been by capture (headward erosion); that a south-flowing stream etched northward foot by foot and offered the north-flowing stream an easier grade southward.

If the col is placed near New Metamoras, as suggested earlier, the capture began there. A field or topographic map study shows that south from here the tributary streams enter the Ohio pointing southward, while upstream many enter pointing northward.

The col was cut before Nebraskan time for the gravel-train of very old Nebraskan (Leverett 1939) gravel is found near Chester, West Virginia, opposite East Liverpool at 1000± feet and at 980 ± at Bellaire. Stream capture is not an unknown process in southeastern Ohio (Leverett 1939; Merrill 1953). This interpretation would give a lower divide on the Ohio River than on any other in southeastern Ohio in Nebraskan time and would explain why the Ohio is the only valley having such old terraces.

Lower terraces are more frequent than high ones on the Ohio. One of these lower terraces can be seen at East End, a suburb just east of the town of East Liverpool. It consists of old weathered glacial gravel and sand, many crystalline pebbles among local (Ohio or Pennsylvania) material none of which is fresh. Cisterns and cellars dug in the terrace do not reach rock. Thickness of the outwash fill is reported to be 15 to 30 ft., and its surface is about 750 ft. above sea level. This material is distinctly older as shown by deep weathering and more weathering than such deposits classed as Illinoian, but not as old as the higher ones just described. It may be evidence of Kansan glaciation to the north. At Wellsville is a similar terrace. In places this material seems more like till, but the weathered sand and gravel constitute most of the terrace.

On the Virginia side, across the river and downstream one to two miles, a great terrace spreads in two levels. The northern portion is about 740 and the southern 760 ft. above sea level. The stream here is below 660 ft. for the 660 contour line crosses at East Liverpool.

Beginning over two miles below Sardis and extending more than six miles along the river stretches a terrace of gravel and sand. A pit opened in this terrace (fig. 2) has a fresh face of 35 ft.; the upper third is yellow sand; lower two thirds is poor weathered gravel. Some fragments of local rock are 3–4 ft. through. Locally, gravel is partly cemented with lime carbonate; but the weathering is far better evidence than is cementation that it is probably an Illinoian terrace.

At New Metamoras, at Grandview, and at Reno near Marietta, are old weathered gravel terraces. Some are roughened by erosion. The terrace at Reno and at Evergreen Motel at Shade, a mile above Marietta, is 7 to 8 miles long, only about 20 to 40 ft. above the present flood plain, and consists of the same old gravel, apparently of Illinoian age. Rock below is not to be seen. Presumably much of the upper part of this terrace has been eroded away. It is a carved terrace of older filling. When the glacier, whose waste is here, came to Ohio, this valley must have been as deep as it is now.

FIGURE 2. Gravel pit in terrace about 3 miles below Sardis, Ohio; upper 10–12 feet is yellow sand, see top bench cut back; lower nearer part is weathered gravel.

Near a place called Gravel Bank a few miles below Marietta, a terrace ½ to 1 mile wide extends 3 to 4 miles along the Ohio River (Ohio side) about 20 ft. above the river (615, 617, ft. above sea level). The terrace has yielded abundant commercial gravel since 1910. While this gravel is well supplied with crystalline pebbles, hence is reworked glacial drift, it may be recent alluvium, really a flood-plain terrace. It is not much weathered in place.

The next down-stream terrace upon which Belpre and Belpre Center have been built, is over 650 ft. above sea level and consists of old weathered outwash material, very sandy at the top where the terrace is well dissected. This is much like the terrace and material found two miles below Sardis but not so bouldery.

Long Bottom is a terrace just above flood level, and while its gravel is rich in crystalline pebbles it is believed to be a modern flood-plain area. Its non-crystalline pebbles are very fresh fragments.

A terrace extending about two miles each side of Portland (fig. 3) is dissected and rises strongly toward the bluffs where it is 620 to 680 ft. above sea level.

The river here is about 550. Material and form, as well as position, indicate this to be a flood-plain remnant. Buffington Island, although 40 ft. above the water, is part of the flood plain. These are mentioned to show the character of the flood plain and to assist in the interpretation of the higher terraces.

At Gallipolis and upstream beyond Kanauga ls a terrace of fresh, recent Wisconsin outwash, whose front is cut into two, and in places, three steps. The Home for Epileptics is on the upper one, which is 100 ft. above the river level.

At South Point, 10 miles above Ironton, the gravel terrace has not been opened commercially, but it seems to be Wisconsin outwash. Ironton spreads over a similar sand-gravel terrace more than 40 ft. high. Down stream a few miles is a larger terrace rising from 540 ft. near the river to 560 near the bluff.

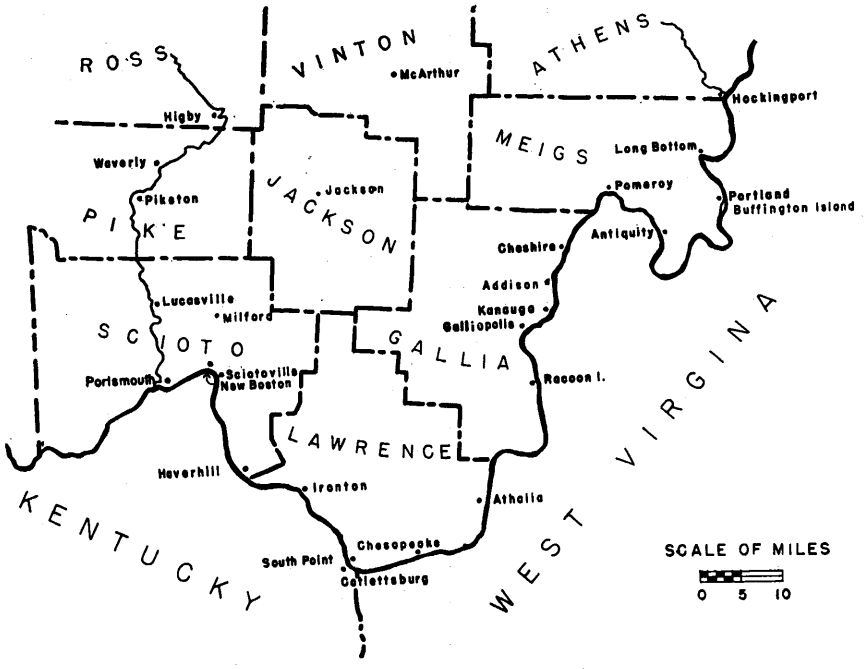

FIGURE 3. Map, Ohio River from Hockingport to below Portsmouth with counties and towns.

River level is about 475 ft. The terrace is gravel with yellow sand on top and has an open gravel pit about a mile from Haverhill. This is believed to be a Wisconsin terrace because of its height and the sand layer on top. Crystalline pebbles are very rare. All tributary streams from here up to Muskingum and Hocking rivers head in unglaciated territory and would add no crystalline material. Thus Ohio waste greatly predominates.

THE MUSKINGUM RIVER

This river heads in many tributaries above Coshocton (Mohican, Tuscarawas, Kokossing) and receives the Licking at Zanesville. Before the Ice Age its waters made their way westward from Coshocton, Muskingum, and other counties through the old Newark Valley, old Cambridge and Groveport valleys to the large Teays River which led westward to and across Indiana and into Illinois (Stout *et al.*, 1943).

The Muskingum Narrows. There seems to be no question but that the Muskingum valley, as interpreted years ago, is made up of two valleys whose

streams headed almost exactly where the Morgan-Muskingum county line comes or, in other words, near Cedar Run 2 to 3 miles south of Blue Rock (fig. 4).

Terraces in Muskingum Valley. Along the Muskingum, where there has been much landsliding, the terrace material often contains masses of waste and fresh rock from the young bluffs. For this reason some of the terraces resemble moraine in form but not in materials. These forms are also distinguishable in some places by the scar on the bluffs from which the waste fell.

As shown above the transgressed col in Muskingum Valley is at Muskingum-Morgan county line. From a mile above Rokely Lock to a mile below is a terrace 40 ft. above the stream and about 700 ft. above sea level. Its glacial gravels are

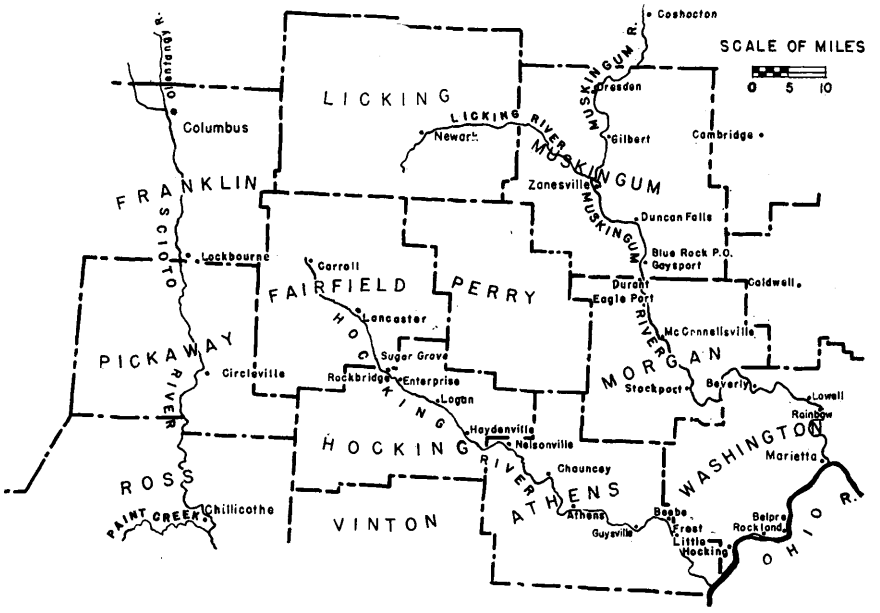

FIGURE 4. Map, Muskingum and Hocking rivers with counties and towns.

being excavated commercially but they are badly weathered and are as old as Illinoian, possibly Kansan. Hence the col just above, at Blue Rock, was transgressed before the Illinoian glacier came, probably initiated by the Kansan or Nebraskan ice sheet. Another terrace of old glacial gravel occurs between Blue Rock and Duncan Falls. Above Duncan Falls and extending nearly to Zanesville is a large gravel terrace, a trifle higher than those down stream. It has been carved into two steps in places and into three in others. A commercial gravel pit has been opened about midway in it, revealing its glacial and badly weathered character.

These terraces, descending gently down stream a little more steeply than the present stream, were laid after the col was cut through and date the cut at least to a pre-Illinoian time. Some seem as old as the oldest on the Ohio River.

At Stockport and McConnellsville, ten miles above Beverly and just above Hooksburg, are extensive gravel terraces mostly less weathered and hence younger than those above described. Several are commercially opened, and the Stockport terrace is carved into two steps about 700 and 733 ft. above sea level. These are classed as Wisconsin. They are far less weathered than the older ones. An example of the very old gravels on Muskingum was found near Lock No. 2, about

4 miles above Marietta. It consists of old gravel and sand, mostly pebbles of granite, gneiss, schist, quartz, and quartzite, often much weathered. There is little Ohio rock recognizable in this terrace at present. At Lakeside Motel just west of the mouth of Sugar Run are similarly weathered, old gravels in the terrace. This terrace is said to rest on limestone. Little ledges can be seen low on the face or front of the terrace.

To sum up, there are terraces on the Muskingum of at least three ages, Wisconsin, Illinoian, and an older stage, probably Kansan. These are all above the present flood-plain terraces. The diversion of water over the col below Blue Rock must have been early enough to permit the new through-stream to carry Kansan outwash and lay it along the valley. There seems no way to invoke headward erosion and piracy, as in the case of the Ohio River, but neither is there any way to prove that the diversion or capture was not done by headward erosion that left no obvious evidences, such as are preserved along the Ohio. The author thinks very early glaciation was the agent that effected the union of two streams to make up the Muskingum.

THE HOCKING RIVER

The Hocking River came into existence during the ice age. A divide extended NE—SW across Hocking, Perry, Morgan, and Muskingum counties separating NW flowing small streams headed for the Groveport River (Stout, *et al.*, 1943) from south-flowing streams headed for the Marietta River and the Teays. Most of these south-flowing streams have been named (Stout, *et al.*, 1943). Hamden started in Hocking County, was joined on the east by Zaleski near McArthur in Vinton County, and entered the old Marietta River and through it the Teays. East of Hamden was Albany River formed by Licking and Chauncey creeks from Perry and Athens counties and flowing across western Meigs into Marietta River in Gallia County. A third unnamed crossed eastern Athens County, and the fourth, Barlow Creek, gathered its waters in Morgan County, and crossed Washington County into Marietta River, very near where the present Hocking joins the Ohio (Stout, *et al.*, 1943).

Hocking Narrows. This arrangement of old drainage accounts for the failure of Merrill (1953) to find evidence of the Teays stage in the Hocking valley. The author has not followed any of these old streams southward in the current terrace study but has seen the divides between them now crossed by the Hocking. The two most notable (Tight, 1903) are the one (Merrill, 1953) east of Haydenville called by the early workers the Nelsonville divide or col, and the one near the village of Frost (fig. 5). The former has been carefully studied by Merrill; the latter has a very narrow valley across it and the bluffs attain their maximum height (800–850 ft.) within a half mile of the stream. Thus the old stream leading to the Ohio (Marietta probably) was only about 8 miles long.

Another narrow place in the Hocking valley is above Logan between Rockbridge and Enterprise. In this area an abandoned valley lies west of the present Hocking course and is filled over 100 ft. deep with outwash. Drainage from the west comes down into this valley, and Buck Run brings part of it out to the Hocking at Rockbridge. Clear Fork brings the rest out farther south entering the Hocking near Logan. No drift is known over the immediate hills in this vicinity. Outwash may have been sent down the valley sufficient to aggrade this abandoned valley to the level of low divides in the present course. This aggradation would send water over the divides until a valley was made lower than the aggraded abandoned valley. Such diversion must have occurred long ago, for the outwash in the abandoned valley is weathered more than known Illinoian, and the current valley is already becoming mature. Merrill (1953) notes Illinoian outwash in several places near and infers that the drainage changes are pre-Illinoian. This author would concur.

Terraces in the Hocking Valley. Leverett makes the point that the Hocking carried much Wisconsin outwash, relatively more than either of the streams so far considered; at least relatively more is preserved. Clear Creek, a tributary that heads farther west in glaciated territory, comes through a gorge from the west and enters the Hocking between Sugar Grove and Rockbridge. Terraces of Illinoian outwash are below the gorge, not along Hocking, but just off Hocking in Clear Creek Valley. They were made after Clear Creek had been forced over the col at its gorge section and when Hocking provided an outlet for it southeastward; hence the Hocking col transgression below Frost must have dated from about the same time, pre-Illinoian.

In the abandoned valley from Rockbridge nearly to Logan, now drained southeastward by Clear Fork, are quantities of Illinoian outwash. The valley is much more mature than the valley now occupied by the Hocking beside it. This modification is pre-Illinoian. Kansas or Nebraskan ice probably came near enough to block the northward flow of the Hocking waters here. Merrill (1953) concurs; others say it is Wisconsin (Stout and Lamb, 1938; Stout *et al.*, 1943). How could it be a Wisconsin diversion with Illinoian or older outwash in it?

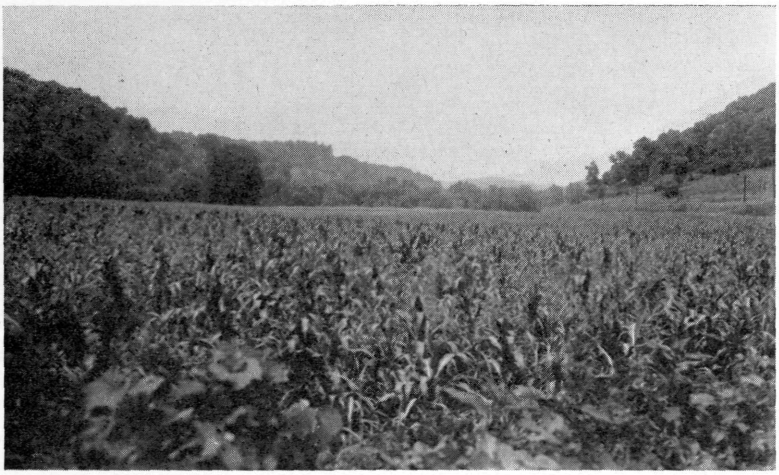

FIGURE 5. Narrows on Hocking, looking down stream from bridge near Frost.

Wisconsin outwash is found in the terraces upon which Logan, Nelsonville, and Athens stand, but upper terraces here as elsewhere are Illinoian. At Enterprise the new road, Route 33, cuts through a terrace 100 ft. above the flood plain. Houses formerly upon it have been removed and a big cut for commercial gravel made. The gravel is dirty, not well sorted, gravel from sand, and carries pebbles up to 8–10 in. in diameter. A layer of fine sand 10–15 ft. thick is on top. There is some cementing and very little weathering.

Another large Wisconsin terrace has been opened between Lancaster and Sugar Grove on the southwest side. The lower half of the gravel is cemented with calcium carbonate. Three miles below Logan, east of the road, is a hill shown on the topographic map to be 220 ft. above the river. It is a remnant of a terrace and has been opened for gravel. It has pebbles of Columbus limestone and many Ohio rocks as well as a wide range of crystalline rocks, shows very little weathering, and is cemented in the lower 25 ft.

From the bridge near Beebe on down below Frost, both villages in Athens County, are several remnants of Wisconsin gravel terrace. Our findings confirm Leverett's point of much Wisconsin outwash in Hocking Valley (Leverett, 1903,

1926) and establish the Hocking stream adjustments as pre-Illinoian with abundant outwash terraces of both stages.

THE SCIOTO RIVER

The Scioto River gathers waters far north in Hardin and Marion counties and flows south across Delaware and Franklin counties. The Olentangy gathers about as far north from Marion and Morrow counties and flows south near the Scioto which it joins in Franklin County at Columbus. The Scioto thus greatly enlarged continues on southward in a broad, open rural valley to the Ohio River in the western part of Portsmouth, passing enroute Circleville, Chillicothe, Waverly, and Lucasville.

Scioto Valley. The Scioto Valley has no narrows as have the others heretofore discussed, but always has plenty of room for its stream with its broad meanders. Its source rivers head far back in glaciated Ohio, for the ice advanced farther south than Circleville over its present head-water area. It has often received not only meltwater from the ice but great quantities of outwash material.

Extended studies by earlier workers showed that the waters flowed northward and have been reversed from Portsmouth about to Franklin County. That the Teays in pre-glacial time flowed from Kentucky into Ohio, in eastern Scioto County, and that the various turns well known in Jackson, Pike, and Ross counties brought waters from the Old Appalachians, the New Appalachians, and the Cumberland Plateau to flow northward in the Scioto Valley through Pike, Ross, and Pickaway counties, then northwestward through Union, Champaign, Shelby and Mercer counties has been gradually worked out. A small Scioto called Portsmouth River flowed northward from the Ohio near Portsmouth to join the great Teays River in Pike County. (Hyde, 1921; Lamborn, 1932; Leverett, 1903, 1926, 1942; Mather, 1909; Stout and Lamb, 1938; Stout *et al.*, 1943; Tight, 1897, 1903).

The reversal of this small Portsmouth River with the part of the Teays that occupied part of the present Scioto Valley has often been noted. The upper Scioto and Olentangy rivers are in almost purely postglacial valleys and are flowing on bedrock almost all their courses. When the reversal came, the Portsmouth offered an easier route to the developing Ohio toward the west than did the Teays; hence that was the route chosen instead of any other, even though it meant cutting out a divide in one or two places on the Ohio below Portsmouth. Thus the Scioto route was laid out for the movement and deposition of outwash.

Terraces in the Scioto Valley. The terraces in the Scioto Valley are of several kinds. A series of rock terraces with glacial gravel caps is described by Leverett (1903), and they are still there. Near Chillicothe the terrace cap stands about 100 ft. above the river and 700 ft. above sea level. The rock terrace is about 600 ft. high. Near the Pike-Scioto County line, about 30 miles south, a similar terrace is known. The gravel top is here 650 ft. above sea level and the rock terrace below it is at 625 ft. Thus the gravel terrace falls southward about 50 ft. in 30 miles while the rock terrace falls northward about 25 ft. in the same distance. The gravelly outwash is about 100 ft. thick near Chillicothe and only 15 ft. at the mouth of the Scioto. The rock shelves are known at a number of intermediate points and on downstream.

This series of rock terraces is good evidence that the river which made it was a north-flowing stream. Topography and many other points are known to support this interpretation. The gravel is undoubtedly old. It has been traced to the Illinoian drift border, and is weathered amply to be Illinoian. If that is its status, the river that made the rock terraces was reversed before Illinoian time. The outwash at Chillicothe (Hyde, 1921; Leverett, 1942) extends below present river level, hence is over 100 ft. thick. A valley was thus carved below the rock terrace before Illinoian gravels were heaped on it. To have so deepened the valley before

Illinoian gravels came, the reversal of Scioto River flow must have been accomplished as early as Kansan time and probably by the Kansan or even Nebraskan ice sheet as it came in over northern Ohio and stopped north and northwest-flowing streams. The process must have been comparable with that disclosed in the upper Ohio and Muskingum valleys.

From Waverly down the Scioto, outwash gravels and terraces are rare, limited to small remnants, but the flood plain is over a mile broad. Thus it seems that if outwash was ever laid along the lower Scioto it has been almost completely removed. Even the flood plain rarely has crystalline pebbles. Weathering and corrosion have reduced them to clay, silt, and fine sand.

From Waverly up river to Higby, over 7 miles, there extends a great terrace of Wisconsin outwash. Its surface is 75 to 100 ft. above the flood plain and is somewhat roughened by small stream erosion, but usually overlaid with a layer of sand. Pebbles of crystalline and Ohio sedimentary rocks are fresh and frequent. The stream-cuts and a large active gravel pit made thorough examination possible. These lines of evidence point to its Wisconsin age, although Illinoian terraces are known nearby. (Hyde, 1921; Leverett, 1942)

Other Wisconsin terraces occur between Chillicothe and Circleville, but these are among the Wisconsin moraines and are all unweathered Wisconsin outwash. The river has certainly played havoc with the outwash deposits once laid in the valley which then corresponded in height with the Waverly-to-Higby remnant.

SUMMARY

The streams that have carved these river terraces in all four valleys are more or less meandering. In places they are quite systematic, but usually they simply wander from side to side planing away a little here and there, undercutting extensively at other places, and again flowing for miles without accomplishing any significant lateral work. This appears to have been their habit for ages, or at least since Illinoian glacial time, because their terraces are not systematic. Some show good form, such as cuspate fronts, divided scarps, and other regular stream-made terrace patterns; but as a rule they have quite the opposite appearance—long, straight fronts, or little notches, uneven steps, and unclassifiable patterns. Nowhere does there seem to be the wealth of systematic detail of pattern found in the Connecticut Valley or in its laterals as at Westfield, Massachusetts.

Correlation. Above current flood plains the materials of the terraces are almost universally of glacial origin, as shown by the abundance of pebbles from out-of-valley and even out-of-state Canadian crystallines.

The materials show differing degrees of weathering. The upper terraces and the materials next to the valley walls have suffered the most disintegration and thereby testify to the extensive duration of time since their placement.

These four streams reach far back into glaciated territory and most certainly carried drainage and waste directly from melting ice fronts and for longer time from areas mantled by drift where the ice lay and melted. We know from widely scattered places and many lines of evidence that the ice came more than once into the general area at northern central United States. Hence there might well be outwash gravels and alluvium of more than one age to account for the varying degrees of weathering and the eroded condition of the terraces.

Our glacialists have drift evidence of four advances (Jerseyan in Western Pennsylvania, Illinoian from Holmes County, southward and southwestward toward Cincinnati, and at least two stages, perhaps three, of Wisconsin age from Butler County north in western Ohio) (Desjardins, 1933; Ireland, 1940, 1943; Lamborn, 1932; Leverett, 1903; Stout *et al.*, 1943, 1953; Ver Steeg, 1931; White, 1931, 1937, 1939) of ice into the Ohio Valley, and from our terraces we can be just as sure of four ages of outwash, Nebraskan on the Ohio, Kansan on the Muskingum, Illinoian, and Wisconsin on all. We are not so far able to distinguish Early,

Middle, and Late Wisconsin terraces. There is one stream diversion, pre-Nebraskan, on the Ohio, probably by a headward erosion capture; a pre-Kansan diversion on Muskingum, probably caused by Nebraskan ice; and pre-Illinoian changes on Hocking and Scioto, probably caused by the Kansan ice sheet. On these four main streams there are no diversions of Illinoian or Wisconsin age. Such were all earlier, but changes on their tributaries can be traced to both later ice invasions. (Frye, 1940; Mather, 1909; Merrill, 1953; Stout and Lamb, 1938; Tight, 1900)

In making use of terraces to unravel river and glacial history it is reasonable to expect to find evidence of any glacial advance in the presence of terrace of that age. In like manner, any area of drift within our river basins may suggest terraces of the same age. Drainage modification attributable to any ice advance may be used as evidence of such advance. There should be no discrepancies or conflicts between evidence from these three sources. There is no doubt but all the several ice advances recorded in central North America were near here somewhere and perhaps advanced farther than we yet can prove. Certainly all the time passed over Ohio that is recorded anywhere else in Pleistocene of central North America. Even if no positive evidence of a glacial stage or of some interglacial interval has yet been found here, we still can bank on all the time here that is required for such events elsewhere.

Flood Plains. All flood plains may be carved into terraces, and all terraces, with the exception of the rock terraces, have been valley trains or flood plains. Even the rock terraces were at stream level at one time as are flood plains today. It might be better to say that the streams were once flowing on the level of the rock terraces. One statement is as true as the other.

In general, one may say a flood plain is a plain along a river but not too high to be subject to floods. Narrow valleys can not have wide flood plains. Wide valleys may have broad flood plains. The Scioto has the widest valley, but its flood plains are not nearly as extensive as they might be if the river should swing laterally enough to remove more of its outwash terraces.

The Scioto has much the largest valley among the four rivers considered in this paper. It has a more mature valley than any of the others. It has no constricted place as have the other three; hence it is believed never to have been modified by headward erosion or by having waters forced over a col between two streams flowing in opposite directions.

There is no place below Columbus where the flood plain of the Scioto is less than a mile wide; and there is no place in any of the other rivers in the section within the scope of this paper where the stream has a flood plain a mile wide. None of the other three rivers have as gentle grade as the Scioto. In the case of the Scioto it is worthwhile to think of the effects of tilting or diastrophic movements in its glacial history. The movements of the land downward as the ice came on and upward as it melted off are not great, only 2 or 3 ft. in a mile, and no doubt there were such movements in the ice-covered portions of Ohio. They were too small to be a factor in what has happened in these rivers, unless it be in the headward erosion in the Ohio. In the Scioto grades are so low and have been for so long that there is more relative chance there for the tilting to be a factor; but since there is no evidence of headward erosion captures in the Scioto, the tilting would only need to be considered in studying and comparing levels of terraces. The rock terraces descending northward, as described above, have a slope gentle enough to be appreciably modified by such tilting as is known to have occurred. It is believed, however, that the depression of the land by the oncoming ice was practically balanced by elevation when the ice melted off, so that consideration of such tilting may be unnecessary in making appraisals of any serious difference in the terrace levels as we find them today.

The author hopes that the above consideration of some angles of our terrace

problems may make a contribution to the study of glacial and river diversion problems.

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